CAUSES AND CURE OF "SMOKY CHIMNEYS."

In the last paper (page 530) it was shown that the cause of the ascending motion of fluids through each other is *gravity*; and we will now proceed to inquire how this principle of *gravity* or gravitation is developed in the action of chimneys.

It will be as well, at this point, to disabuse the mind of the very common error, that "draught" is the *cause* of action; and it will afterwards be seen that *draught* is altogether an improper term to apply to this action. "Draught," or more properly *current*, in chimneys, is merely a *consequence*, and not a *cause*. It is the action itself, and not the cause of action; and in using the term draught hereafter, we will do so merely because it is already a familiar term, and may, therefore, conduce to the easier understanding of our subject, but must be understood to mean simply the *current* of smoke or air in chimneys, without reference to the *cause* of such current.

We have already seen why smoke rises, and it is, therefore, easy to perceive that the smoke from a fire would ascend, whether there was a chimney to receive it or not. But let us take two fire-grates of similar construction and equal dimensions; and fix one with, and the other without a chimney, and light a fire in each at the same time. As they continue to burn, we shall find that the smoke rises much quicker from that with the chimney to it. Whence, then, proceeds this difference?

It has been shown, that in the case of all fluids differing from each other in specific gravity, or weight, bulk for bulk, the lighter fluid will ascend through the heavier. This it will do with a velocity proportionate to the difference of their specific gravity; *i. e.* the greater the difference of weight, the quicker; and the smaller the difference, the slower will the light fluid ascend through the heavier. The same law that governs this motion of different fluids through each other affects equally each particular class of fluid with which a difference, or variation of specific gravity, or weight, can be produced amongst its own particles. For instance, if a portion of the contents of a vessel of water be rendered lighter than the remainder, the lighter portion will ascend until it reach the surface. By the aid of *heat* this can be done. A gallon of *hot* water is lighter than a gallon of *cold*; and hence, we find that a cauldron of water in process of heating is always the hottest near its surface. It is the same with air. To pursue the simile: a gallon of *heated* air is lighter than a gallon of *cold* air; and therefore it is that the heated air of a chamber always rises to the ceiling.

Air, as a fluid, differs from water in this respect, inasmuch as it may be made lighter by other means than by the application of *heat*: viz. by mechanical influence upon the property of *elasticity*, which it possesses in a very high degree, but which water possesses to such an insignificant extent that it is classed amongst, what are technically termed, *inelastic* fluids. In reference to our present question of "draughts," or currents in chimneys, only the first mentioned property of air requires to be considered, viz., that of becoming lighter by being subjected to heat; but before tracing their connection any further, we will endeavour to demonstrate the fact, that all bodies, solids included, become lighter by the application of heat.

The absorption of *heat* by any substance whether in a solid or a fluid form, causes such substance to expand; or, in other words, to occupy a greater space than it did before the *heat* was applied. For example,—take a piece of cold bar iron of any breadth and thickness, but exactly 12 inches long, and heat it uniformly until it attain a bright "red heat;" it will then be found, on measuring, to have expanded or increased in length, about 1-8th of an inch, or nearly 1-120th part of its whole length, and will therefore measure 12⅛th inches in length. Again, let a vessel containing exactly one gallon of water when filled to the brim, be placed over a fire or lamp;—it will be seen that as the water *heats*, it will commence, and continue to flow over the edge of the vessel, long before it reaches the temperature at which it commences to boil; and if the heating be continued until it reach the boiling point, and the water be then allowed to cool down to its original temperature, it will be found that about 1-3rd of a pint, or 1-24th of the whole quantity has overflowed; and therefore that it has expanded about 1-24th of its original bulk by being heated to the boiling point. In like manner, air, by being heated, expands and occupies a larger space; for, if we take a bladder and fill it about 3-4ths with air by blowing into it, then tie the neck firmly to prevent leakage, and hold it before the fire; in a few minutes the air will expand and fill the bladder.

Now, in proportion as this expansion proceeds in bodies, so do they become lighter; for it will be obvious by the above experiments, that if the expanded 1-8th of an inch, or 1-120th of the whole length, of the heated iron bar were cut off, it would be 1-120th part shorter, and therefore 1-120th part lighter. In the same way, the water, having expanded and lost over the edge of the vessel 1-24th of its bulk, must be 1-24th less than when it was cold, and will therefore weigh 1-24th less than its original weight. And, by heating the air in the bladder to the same temperature as that of boiling water, viz., 212 deg. Fahrenheit, it would expand 1-3rd of its original bulk, and would therefore be rendered 1-3rd lighter.

With solids, and all fluids except those that exist in the *gaseous* form, there is a limit to the amount of expansion by heat which they are capable of: for instance, at a certain temperature iron melts or becomes fluid, ceases to expand, and, uniting with the oxygen of the atmosphere, forms the oxide of iron; and water, at the boiling point, ceases to expand, and forming into vapour or steam, flies off into the atmosphere. But to the expansion of *gaseous fluids* by heat, there is no limit save that which limits the power of generating *heat*; *atmospheric air* may therefore be expanded to an indefinite degree.

This property of expansion, when applied to atmospheric air and other gaseous fluids, is called *rarefaction*; and we will presently see that the *rarefaction of air* is, in every case, the cause of "draughts" or currents in chimneys. We will first establish this fact in relation to chimneys in use, and will then account for the draughts which may be frequently found in those not in use.

First, then, let us suppose an ordinary room, in which a fire-grate is set in the usual way, and filled with fuel ready for lighting. The temperature of the room being the same as that of the external atmosphere, the column of air in the chimney will balance, and be balanced by the surrounding atmosphere as explained by fig. 4 (page 530). Now place a lighted candle to the throat of the flue, and it will be seen that no "draught" exists in consequence of there being a perfect balance between the air in the chimney and that outside. On putting a light to the fuel there is at first a dense volume of gas or *smoke* evolved from it, which, being specifically lighter than the atmosphere, ascends through it; and entering the chimney, passes up and out at the top, pursuing its ascent until it becomes dissipated by mixing with the other gases of the atmosphere. It does not ascend because the chimney is there to receive it, nor by virtue of any "draught" in the chimney, because it has been shown that there was none a moment before lighting the fuel. Its ascent up the chimney is then, in the first instance, owing entirely to its superior lightness, and it would ascend with equal rapidity at that instant, were the firegrate in the open air with no chimney above it.

But let us mark the progress of the kindling fire. There has been, as yet, no *rarefaction* effected in the chimney, because there has been no *heat* applied to the air; consequently, there is no "draught." Smoke or coal gas continues to be evolved from the fuel, and its temperature being greater than that of the air in the chimney, the latter is gradually heated beyond the temperature of the surrounding atmosphere; it therefore becomes lighter, and, the balance being destroyed, it is forced upwards by the pressure of the colder, and therefore heavier, air of the room, and the "draught" commences. As the fire continues to increase, so does its power of *rarefaction*, and a *current* or "draught" once created, there is a constant flow of air towards it, each successive portion of air presented to its action being made hotter, more *rarefied*, and therefore lighter than the last; so that the "draught," or *current*, increases in velocity as the fire increases in strength, continuing to do so until the fire attains its greatest heat.

This effect of "*rarefaction*," or expansion of air by *heat*, may be explained by the following experiment:—Let AB, Fig. 5,

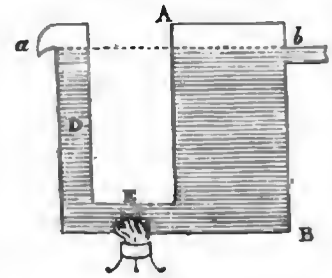

Fig. 5.

represent a vessel filled with water supplied by a pipe C, so arranged as to maintain the surface of the water at the level of the line *ab*. D is a pipe open at the top, and standing perpendicularly to the same height as the vessel AB, to which it is connected by a horizontal pipe E, so that the water in it shall stand at the same level as in the vessel AB—*i. e.* at the level of the line *ab*. The temperature of the water being uniform, the specific gravity or weight will be the same in both; the column of water in the pipe D will therefore balance that in the vessel AB, and the whole will remain in a state of quiescence. Now if a fire or lamp be applied to the middle of the horizontal pipe at E, as shown in diagram, it will impart *heat* to the water, which heat will be given out in equal quantities both ways; *i.e.* the same quantity of heat will pass along the pipe E into the upright pipe D as passes in the opposite direction into the vessel AB. But the vessel AB contains a much greater quantity of water than the pipe D, and the quantity of heat supplied to both by the fire at E being equal, it follows that the water in D will heat much sooner than that in the vessel AB; and therefore that at any given point of time after the fire has been applied the temperature of the water in the pipe D will be found to exceed that in the vessel AB.

It has been shown that as a fluid becomes heated so does it become lighter; the specific gravity or weight of the column of water in the pipe D must therefore be less than that in the vessel AB. This being the case, the balance existing between the two columns before the application of the fire will be destroyed; and the colder, and therefore heavier, column in the vessel AB will overbalance the lighter column in the pipe D, and cause it to rise and overflow the top of the pipe at *a*. The surface of the water in the vessel AB will, at the same time, have a tendency to fall, but the supply instantly afforded by the pipe C will prevent it from doing so, and will maintain the level of the water at the line *ab*. The preponderance of the column in the vessel AB being thus kept up whilst the fire at E continues to impart heat, a continuous stream will flow through the pipes E and D, issuing from the top of D, and this stream will increase in velocity as the strength of the fire increases, until it arrives at that point where the continual supply of cold water to the pipe E will neutralize the heat-imparting power of the fire.

Now, if we imagine *atmospheric air* to be the fluid used in the above experiment instead of *water*; and take the pipe D to represent a chimney, the vessel AB a room, the pipe C the door and other apertures through which a supply of cold air enters, and the lamp at E the fire, we have before us a complete practical illustration of the fact that the rarefaction of air by heat is the cause of the currents in chimneys commonly, though erroneously, called "draughts."

The term *draught* signifies that peculiar motion of matter where a moving body is drawn after or follows the power which produces the motion, and is directly dependant upon it for its onward progress. Thus the cart is drawn by the horse; or, if we lower a bucket into a draw-well and raise it again to the surface filled with water in the usual way, we *draw* it to the surface; and the motion of the water from the well in such case is *draught*. Now, we have already seen that one fluid rises